APPENDIX A
(of FRCRM Watershed Monitoring Program Final Report 2/2004)

Feather River Coordinated Resource Management
Pilot Watershed Monitoring Program
319(h) Clean Water Act Grant
Final Report

Prepared by Plumas Corporation
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Summary

In 1997, a Clean Water Act 319(h) granted was awarded to the Feather River Coordinated Resource Management (FRCRM) group to develop a Pilot Program for regional watershed monitoring in the upper Feather River basin. The specific purpose was to develop, field test, and evaluate protocols of a watershed monitoring network to obtain baseline and/or continuing data from which could be measured trends-through-time of watershed health. The general purpose was to begin a program of trend analysis with which to evaluate changes as they relate to land management and restoration efforts in the watershed.

The Pilot Program established twenty-one (21) permanent reference reaches (from which field data was collected on nine (9) physical, and two (2) biological parameters), two (2) sediment sampling sites, and eleven (11) continuous recording stations (which track stream-flow, water temperature and several water quality parameters). These are located in the North Fork (1100 mi^2), East Branch (1000 mi^2), and Middle Fork (1200 mi^2) watersheds as follows:

Watershed	**Reference Reaches**	**Continuous Recording**	**Sediment**
North Fork Feather	5	0	0
East Branch Feather	12	10	2
Middle Fork Feather	4	1	0

The field methods used in the reference reaches follow closely those described in the US Forest Service "Stream Condition Inventory Guidebook", version 4, 1998.

The Pilot Program was planned and developed in 1997- 98. The field data was collected from the reference reaches in 1999. The installation of equipment at the continuous recording sites was accomplished in 1999- 2000. The selection of sediment sites was made in 1999, with data collection initiated in 2000- 01.

As a special contribution to this system, Ca. Department of Water Resources purchased and installed a satellite-accessible weather station at Doyle Crossing in the Last Chance Creek watershed (upper east Branch).

Background and Setting

The Feather River Coordinated Resource Management (FRCRM) group, a proactive consortium of 21 public agencies, private sector groups, and local landowners (Table 1), was formed in 1985 in response to widespread erosion and channel degradation in the Feather River watershed. The FRCRM has collectively completed over 50 watershed projects in the Feather River basin since 1985 including studies and assessments, resource management plans, stream restoration projects, community outreach and educational efforts. Over 15 miles of stream and 4,000 riparian acres have been treated at a cost of over five million dollars, which was contributed largely by FRCRM partners. The goal of the FRCRM program is to improve watershed condition over time, reduce erosion, restore meadow function, improve water quality and enhance habitat for fish and wildlife.

Table 1: Feather River Coordinated Resource Management Signatory Members

California Department of Forestry & Fire Protection	**Plumas County**
California Dept. of Fish & Game	**Feather River College**
California Dept. of water Resources	**Pacific Gas & Electric**
California Regional Water Quality Control Board	**Plumas Corporation**
USDA- Natural Resources Conservation Service	**USDA- USFS, Plumas National Forest**
U.S. Army Corps of Engineers	**Plumas Unified School District**
Feather River Resource Conservation District	**USDA- Farm Services Agency**
California Dept. of Transportation	**Salmonid Restoration Federation**
California Dept. of Parks & Recreation	**U.S. Fish & Wildlife Service**
Plumas County Community Development Commission	**Univ. of Calif. Cooperative Extension**
North Cal-Neva Resource Conservation and Development Area	

The Feather River watershed is located in California's northern Sierra Nevada, where the North, South and Middle Forks drain 3,222 square miles of variable terrain from the Great Basin Escarpment westward through the Sierran crest into the Sacramento River (Figure 1). The study area includes three (3) USGS Hydrologic Unit Code watersheds: HUC #18020121, North Fork Feather; HUC #18020122, East Branch, North Fork Feather; HUC #18020123, Middle Fork Feather. Elevation ranges from 2,250 to over 10,000 feet, and annual precipitation varies broadly from more than 70 inches on the wet western slopes to less that 12 inches on the arid east side. Vegetation is diverse and ranges from productive mixed conifer and deciduous forests in the west to sparse sage/yellow pine plant communities in the east. The Plumas National Forest manages most of the forested uplands while the mid-elevation alluvial valleys are predominantly in private ownership.

The Feather River watershed has long been recognized for its recreational and aesthetic value. An abundance of montane rivers, lakes and reservoirs grace the landscape, creating both summer and winter recreational opportunities. Water originating from this area represents a significant component of the State Water Project, which provides high quality water to meet downstream urban and agricultural demand. In addition, a series of hydroelectric dams, powerhouses and reservoirs produce over 4,000 MW of power, while the watershed produces significant forest and agricultural outputs. Water is, therefore, a valuable commodity in this resource-dependent community, and maintaining stable watershed condition is a key element in promoting economic and environmental stability.

The Feather River watershed has been impacted by 140 years of intense human use. Mining, over-grazing, timber harvesting, wildfire, railroad and road construction effects have all contributed to a watershed-wide stream channel entrenchment process. This entrenchment resulted in accelerated erosion, degraded water quality, decreased vegetation and soil productivity, and degraded terrestrial and aquatic habitats. Functionally, the disconnection of stream channels from their floodplains and meadows has led to a dramatic change in hydrology, leading to reduced summer flow, higher summer water temperature, lower water tables, reduced meadow storage capacity, and a trend from perennial to intermittent flow. Many downcut streams no longer sustain late-season flow, causing adverse consequences to riparian and upland vegetation, aquatic communities, and downstream water users (Ponce and Lindquist 1990).

The FRCRM recognized that restoring watershed function was a major priority for reversing erosional trends. Stable, well-vegetated streams with functioning meadows, aquifers and uplands are critical in maintaining good watershed condition. Achieving this stable state begins with reestablishing water and sediment retention and release functions in headwater meadows, which is the current focus of the FRCRM (Lindquist and Wilcox 2000). Restoration activities play an important role in accelerating improvement in watershed function, the local economy and downstream uses. The results of this monitoring program will help the FRCRM assess the long-term trends in watershed condition in response to projects and may provide useful information in the future to help prioritize limited restoration funding to areas of greatest need.

Project Work Plan

The pilot monitoring program was developed in 1997-1998 under the guidance of FRCRM Monitoring Technical Advisory Committee (TAC). The program was implemented over a two-year period, from 1998-2000. The first year focused on developing a strategy and work plan (Appendix A) that was realistic, feasible and met project objectives. Data collection took place the second year of the project for both the reference reach and permanent station components which is described in more detail in the *Sampling Design and Protocol* section of this document.

The overall objectives of this program are to:
- Develop, implement and evaluate a monitoring program which documents, at the watershed scale, long-term trends in watershed condition cumulatively resulting from restoration activities, land management changes and natural processes in the Feather River basin.
- Develop a spatially referenced data management system to track, organize, and store monitoring data, facilitate analysis, provide a means for widespread distribution and education, and support production of reports needed to evaluate long-term trends. The system used should be compatible with other data sets managed by Quincy Library Group (QLG), Department of Water Resources (DWR), USFS, and others.
- When possible, use monitoring protocols currently used by resource management agencies to facilitate data sharing and to improve data analysis.

The monitoring approach consists of three basic components designed to address project objectives. They are:
- ♦ Biennial monitoring of physical and biological parameters at 21 designated permanent response reference reaches.
- ♦ Installation of 11 permanent recording stations where data loggers continuously record streamflow and temperature data, and where water chemistry samples are collected manually.
- ♦ Regional physical and climatic data are collected at a newly installed weather station at Doyle Crossing. This weather station was purchased and installed by CDWR as a contribution to the project ($25,000). The Doyle Crossing weather station is satellite-accessed, with real-time data available through the Ca. Data Exchange Center (CDEC).

Major tasks carried out in this pilot program include:
  - ▪ the development of a monitoring work plan;
  - ▪ purchase and installation of monitoring equipment;

- reference reach initial surveys;
- direct measurements of stream flow for rating permanent stations;
- collection of turbidity, flow and stream temperature data via data logger;
- manual collection of water chemistry samples;
- development of a GIS-based data management system and web interface;
- installation of one meteorological station;
- securing landowner agreements to access equipment and collect data on private land;
- identify and secure funding for the monitoring program beyond the two year pilot phase.

1. Sampling Design and Protocols

Reference Reach Monitoring

Objective: Monitor physical and biological parameters in selected reference reaches at 21 locations in the watershed on a biennial basis. The data is expected to provide a baseline condition with which to discern changes in watershed condition resulting from land management, restoration and natural processes.

Reference reaches were selected based on several criteria. The major criteria include channel sensitivity to change, current and future management activity, accessibility for data collection, position in the watershed and reach length. From a monitoring perspective, we are more interested in sensitive or response reaches since these sites react more quickly to changes in management and natural events, and therefore, will demonstrate change more readily in a long term monitoring program. The selected reaches should be representative of the system. Sites selected for this program are characterized as low gradient, alluvial and have minimum on-site disturbance to avoid data "noise". The reaches are located at or near the base of each sub-watershed to provide a cumulative measure, and are at least 20 channel widths in length (which is the designated minimum length of each reference reach).

The fieldwork for reference reach data collection is conducted by a team of trained technicians that are supervised by an experienced crew leader with extensive field and data collection experience and a technical background in hydrology and biology. To the extent possible, the fieldwork will follow scientific procedures and protocols that are well established in the primary literature or common practices of federal or state resource agencies in the watershed. Data quality control is discussed more fully in the FRCRM Quality Assurance Protection Plan (Appendix B) prepared as part of this CWA 319 grant.

Sampling Approach

The monitoring approach relies heavily on established procedures developed by resource management agencies and on collective expertise offered by FRCRM contributors. It was designed particularly in terms of assessing changes in channel structure, habitat and water quality factors. Field sampling procedures are based on protocols described in the "Stream Condition Inventory Guidebook" (SCI) version 4.0 (1998) (Appendix C). These protocols were developed over a five-year period (1993-98) by fisheries biologists and hydrologists in the US Forest Service Region 5, with support for sampling design and statistical analysis from the USFS Pacific Southwest Research Station. SCI methods were critiqued and in some cases modified by the FRCRM Monitoring Committee to meet project needs. Parameters included in the sampling design and the location of reference reaches are listed on Table 2.

The intent was to provide protocols that can be consistently applied in assessing and monitoring stream conditions in the Pacific Southwest Region, which includes the Feather River basin. Attributes were tested that had been demonstrated through research to be indicative of stream condition, could be sampled by seasonal field crews, and yet had low enough measurement error to be useful in describing changes in stream habitat with a moderate to high level of confidence. The intensity of data collection meets the objective of comparing data over time, or from other streams with a reasonable level of statistical confidence.

Biennial reference reaches were established at the locations listed in Table 2 below. Physical and biological data collected at each reach is listed. Location of each site in the watershed is shown on Figure 2.

Table 2: Enumerated Reference Reaches

Reach #	Location	Reach #	Location
1.	NFFR above Lake Almanor	12.	Indian Creek at Taylorsville
2.	Goodrich Creek above Mountain Meadows Reservoir	13.	Indian Creek acw Spanish Creek
3.	NFFR below Lake Almanor	14.	Spanish Creek acw Rock Creek
4.	Butt Creek above Butt Valley Reservoir	15.	Greenhorn Creek acw Spanish Creek
5.	NFFR acw** EBNFFR	16.	Spanish Creek acw Greenhorn Creek
6.	EBNFFR acw NFFR	17.	Spanish Creek acw Indian Creek
7.	Wolf Creek above confluence with Indian Creek	18.	Middle Fork Feather River (MFFR) at Beckwourth
8.	Lights Creek acw Indian Creek	19.	Sulphur Creek acw MFFR
9.	Last Chance Creek acw Red Clover Creek	20.	Jamison Creek acw MFFR
10.	Red Clover Creek acw Last Chance Creek	21.	MFFR acw Nelson Creek
11.	Indian Creek acw Red Clover Creek		

**acw = above confluence with

Reference Reach Data Collection

Monitoring is conducted on a biennial basis. Physical and biological parameters are listed below:

- ***Channel morphology***, including channel cross sections, channel slope, channel substrate sampling, and pool tail fines. Transect data includes bank stability, shade, width/depth ratio, stream shore water depth, and bank angle. Bankfull discharge will be estimated based on these measurements.
- ***Water chemistry***, including water and air temperature.
- ***Habitat***, including spatial distribution of fast and slow water via longitudinal gradient (i.e. pool and riffle orientation), pools (size, depth and number), pool tail substrate, shading, and stream bank stability (i.e. vegetation cover).
- ***Macro-invertebrates***, including analysis of population numbers and species diversity in comparison to Sierra Nevada reference sites. Not originally part of SCI protocol, but has been added on with the availability of reference site data.
- ***Aquatic fauna***, including fish surveys to identify species present and herpeto-fauna.
- ***Aerial and ground photographs***, to provide visual documentation of instream and upland changes in vegetation and channel structure, and to support other monitoring results.

Results of long-term data analysis will be integrated with other Feather River watershed monitoring activities underway or contemplated by the USDA Forest Service, DWR, UCCE, QLG and others. A Technical Advisory Committee (TAC) composed of FRCRM Monitoring Committee members, agency specialists, and academic reviewers provided technical guidance and oversight on the implementation of the project. The TAC members were identified in spring 1999.

2. Permanent Station Monitoring

Objective: The primary objective of the permanent monitoring stations is to record stream stage over a broad range of flow conditions in order to provide a comparative measure of the changes at each station over time and to possibly detect changes in hydrographic conditions related to stream restoration efforts. Secondary objectives to provide comparative measures of expected changes at each station over time include monitoring stream temperature, and air temperature at each location. The water temperature provides supplemental information regarding the condition of the channel upstream of the monitoring site as well as some indication of the source water's characteristics. Air temperature can be used to explain behavior of water temperature as well as some hydrographic events. Water quality samples are collected manually to allow for further analysis of the origin, age and movement of in-stream flow.

Sampling Approach

Eleven sites were identified as appropriate permanent sampling stations. The name and respective data collection for each station are listed in Table 2. Criteria used to select a site include the existence of a bridge that equipment could be bolted to (one exception), a relatively stable location to install sensors, good access and a lower position in the respective drainage.

For Permanent Station monitoring, most data is being collected electronically and downloaded by field personnel on 60-day intervals. The equipment installed, discussed below, is state-of-the-art and is maintained and downloaded by experts familiar with the geographic area and the equipment. Technicians working with the FRCRM have extensive experience on with this equipment and bring that expertise to the FRCRM program.

Samples collected at permanent stations are listed in Table 3 below. Location of each site in the watershed is shown on Figure 3.

TABLE 3: Measurements taken at permanent stations

Station #	Location	Stream Flow & Temp.	Staff Gage	Weather Station*	Sediment & Turbidity	Water Quality
1.	Last Chance Creek at Doyle Crossing	X	X	X		X
2.	Red Clover Creek at Notson Bridge	X	X			X
3.	Indian Creek at Taylorsville	X	X	X	X	X
4.	Indian Creek at Flournoy Bridge	X	X			X
5.	Middle Fork Feather River at Sloat		X			
6.	Indian Creek above confluence with Red Clover	X	X			X
7.	Spanish Creek at Keddie (existing USGS)	X	X			
8.	Spanish Creek at Gansner Bridge	X	X			X
9.	Wolf Creek at Greenville Main Street Bridge	X	X		X	X
10.	Lights Creek at Deadfall Bridge	X	X			X
11.	Indian Creek at Crescent Mills	X	X			X

* Data taken at weather stations includes: rainfall, temperature, relative humidity, wind speed, wind direction, atmospheric pressure.

Permanent Station Data Collection

Monitoring is conducted continuously for data collected by data loggers, and on 60-day intervals for manually collected data. Parameters are listed below:

- Continuously monitor ***water temperature*** and ***stage*** at eleven permanent sampling stations with a Campbell 500 data logger system;
- Conduct continuous ***turbidity*** monitoring during high flow seasons at two stations with a laser sensor;
- Collect ***conductivity, pH, and isotopic samples*** manually at all stations during routine maintenance of data loggers;
- Collect ***bedload and suspended sediment*** data in various flow regimes at two stations;
- Collect ***flow*** data at various stages to produce stage/discharge rating curves for each station, and
- Collect ***climatic data*** at two installed meteorological stations that are linked via satellite to the CDEC database. Data includes relative humidity, temperature, wind speed, wind direction, atmospheric pressure, evapo-transpiration, solar radiation and precipitation.

Equipment Installation

Following an evaluation of available monitoring equipment, the study team chose the CR10X datalogger and associated equipment manufactured by Campbell Scientific to instrument each site. Table 4 and Table 5 provide details regarding the instrumentation deployed at each permanent station. This Campbell equipment was chosen largely based on the long-standing presence of the manufacturer in the remote monitoring market place and the reputation of product reliability. The CR10X was selected because of its ease of programming, flexibility and expandability.

Stream stage is measured using standard pressure transducer technology. Pressure transducers were selected because they provide acceptable accuracy while allowing rapid low cost deployment. The selected Druck 5-psi pressure transducers are accurate to ± 0.01 ft. over a range of 11.53 ft. These units have a typical life span of approximately 5 years. Pressure transducers measure the depth of water over the sensor probe, which is converted to the reference gage height using a site-specific mathematical formula. The reference gage heights are then used in conjunction flow measurements to develop a stage/discharge rating table that can be applied to the collected data from the instrument

The primary problem associated with transducers is a drift in relative accuracy. This drift can be due to age, changes in barometric pressure, and extreme ambient temperatures. The inaccuracies associated with changes in barometric pressure are minimized through the use of a vent tube from the sensor to the atmosphere. Fluctuations related to changes in temperature are calculated to be less than the accuracy resolution that is required of the instrument. Accuracy drift related to age can be accounted for with a strict QA/QC policy that evaluates change in transducer readings compared with reference gage heights.

Table 4:Permanent Station Monitoring Equipment

Equipment Description	**Deployment Location**
Datalogger (Campbell CR10X)	All stations
Air temperature sensor	All stations
Gill radiation shield	All stations
Druck 5 psi transducer	All stations
Turbidity (Analite 195)	Taylorsville, Doyle Crossing
Water temperature sensor	All stations
Battery (33 amp/hr gell cell)	All stations
Solar Panel	Doyle Crossing, Notson Bridge
Lockable enclosure (sealed)	All stations
Protective enclosure (metal)	All stations
Stilling well /probe attachment	All stations

Table 5: Permanent Station Installation Information

Station	Stream	Installation Date	Station Configuration
Notson Bridge	Red Clover Creek	10/22/1999	Full station installation
Taylorsville Bridge	Indian Creek	10/29/1999	Full station installation
DWR Weir	Indian Creek	11/04/1999	Full station installation
Flournoy Bridge	Indian Creek	11/05/1999	Full station installation
Doyle Crossing Bridge	Last Chance Crk	11/19/1999	Up-graded existing
Wolf Creek Main Street	Wolf Creek	12/21/1999	Full station installation
Deadfall Bridge	Lights Creek	12/28/1999	Full station installation
Moccasin Reef at Hwy. 89	Indian Creek	01/06/2000	Staff gage only
Spanish Creek at Quincy	Spanish Creek	Pending	Full Station Installation Spring, 2001

Installation Methods

The specific method of equipment installation at each site was determined during scoping surveys conducted in April 1999. The location of each station is associated with a road bridge or flow control structure to help facilitate installation. Installation methods consisted of installing a permanent probe-mount housing in the stream below the minimum expected water level. The probe-mount housing was typically mounted to the bridge pier or bedrock. The primary objective of this type of installation is to prevent any movement in the probe-mount housing during high flow events.

A protective metal enclosure was then installed on the bridge or other suitable structure above the anticipated high water level. A sealed instrument enclosure was mounted inside the protective metal enclosure. Flexible and/or rigid conduit was then buried and/or attached to the bridge structure to provide a protected channel for the probe cables between the metal enclosure and the in-water probe-mount housing.

The probes were mounted inside the probe-mount housing using an aluminum pinch block. This method of attachment allows for a secure immovable attachment with ease of maintenance and repair of the equipment.

The CR10X data loggers were then installed and data collection initiated. The data loggers were programmed to sample stream stage and temperature every 15-minutes and using this data calculate and record an hourly average. The loggers were also programmed to roll-up the 15-minute information on daily basis, calculating the daily maximum, minimum, and average stream stage, and average daily stream and air temperature. Other parameters (instrument operation) were also included in the daily roll-up.

In addition to the pressure transducers a reference staff gage was installed at each station. This provided a permanent reference to facilitate checking transducer drift and providing a cross-reference to previous data when the transducer needs to be repaired or replaced.

Installation of the monitoring stations was begun in October 1999. Specific installation information for each station is included in Table 3. Seven of the eight permanent stations were installed by January 2000. The station at Spanish Creek was not installed as a result of logistical delays and the onset of high flows which prevented the attachment of the probe-mount housing below the minimum water level. Installation of the Spanish Creek station is scheduled for spring 2001. The existing station on Last Chance Creek at Doyle Crossing was upgraded with the installation of a CR10X to conform to the other stations in the monitoring network.

Flow, sediment and water quality monitoring

Discharge measurements at differing stages have been taken at eight locations. These measurements are taken on a measured cross-section with a Price 622 velocimeter mounted on a rod for wading or suspended by cable from a bridge crane, bridge board or truck mounted boom as needed. The protocol for these measurements is detailed in the QAPP. This data will be used to develop flow rating curves once enough points have been established.

Suspended sediment data will also be collected at two permanent station sites (see Table 3). Data will be collected using either a rod or cable system as per flow measurements above. The protocol for this sampling program is detailed in the QA/QC. Minimal turbidity and suspended sediment measurements have been collected due to relatively low flows and equipment delivery delays for the year 2000 winter period. No bedload sampling has been undertaken for the reasons stated above.

FRCRM staff manually collects water quality data when data loggers at permanent stations are downloaded, usually on 60-day intervals. This is an ancillary monitoring component conducted at the request of Plumas Geo-Hydrology and Desert Research Institute (DRI). The purpose is to analyze the naturally occurring chemical and isotopic characteristics in order to determine the origin of the water (surface, shallow meadow, deep aquifer, etc.) by season. DRI has offered to conduct the analysis so samples are labeled and sent to their facilities in Reno, Nevada.

Data Management and Analysis

The data will be used to provide a baseline from which to monitor long-term trends in the condition of the Upper Feather River watershed. It will also be used to document trends in watershed condition cumulatively resulting from restoration activities and natural events. To facilitate this comparative analysis, a series of Excel spreadsheets have been developed by Ken Cawley (Feather River College) for reference reach data and by Mike Kossow and Tim Sagraves (consulting watershed specialists) for permanent station data. (Water chemistry data is being analyzed separately by Desert Research Institute so is not discussed here). The spreadsheets are formatted to store the data as it is collected (in the case of data loggers) and to facilitate trend analysis. They are linked to a spatially referenced data management system or Geographic Information System (GIS) that was developed by the CDWR and California State University Chico scientists. Data layers will be set up for each parameter consistent with layers already developed by the Plumas National Forest to encourage data sharing. The data will be distributed via the FRCRM website and through the data “clearinghouse” on the California State University Chico website.

These data will provide critical input to the restoration program conducted by the FRCRM. Identification of conditions throughout the watershed will allow prioritization of restoration projects in terms of location and goals. This data may also be useful in quantifying the benefits of past restoration efforts. Information on watershed condition will serve as baseline data for future projects.

The data and analyses will be available to a wide resource management audience, including local land management agencies, academics and private landowners. These data will hopefully inform land management decisions made by many organizations and individuals, which have the potential of affecting the Feather River watershed. In addition, this information will be useful to the public to gain insight on the overall condition of the Feather River watershed, and the connections between land use, restoration, and watershed condition. The data will be made available to a broad audience through the FRCRM website and through the CSU Chico website as previously mentioned.

Reference Reach Data

Reference reach data was collected in four passes along the stream, as detailed in the QAPP (Appendix B). The tables in Appendix D summarize all data for the Greenhorn Creek acw Spanish Creek Reference Reach is included as an example of the data output and how the spreadsheets are formatted. The raw data for all passes is currently stored at Plumas Corporation and is available to FRCRM members upon request. Due to the vast amount of raw data, data made available via the Internet for broader distribution will generally be in the summary table format.

Macroinvertebrate samples were collected, labeled and stored as described in the QAPP. The National Aquatic Monitoring Center, Utah Dept. of Fish & Wildlife, Ogden, Utah, which was recommended by Plumas National Forest staff, will process the samples. Samples will be sent out for identification once the Ambient Water Quality Monitoring contract is in place.

Water and ambient air temperature is monitored at each reference reach site with HOBO Temp data loggers. The temperature loggers are installed at the lower end of each reach in early June and collected in early September. Temperatures will be recorded to determine mean maximum temperature for the period July1- August 31. The full temperature range for this period will also be recorded through hourly measurements for a minimum of 1468 data points (1 hr./62+ days). Software will be provided by the Lassen National Forest to manage and analyze the data.

Channel substrate samples are processed using nested sieves for <4mm particles and a millimetric ruler for >4mm particles. The purpose is to quantify the bed characteristics by weight/particle size class. This information will provide baseline information with which to compare future bed composition changes relative to watershed restoration projects, management changes and natural processes. This sampling methodology is more sensitive to changes in finer sediment classes (<2mm) than the standard Wolman pebble counts.

Permanent Station Data

The Campbell data loggers record stream stage, along with ambient air and water temperature data, in fifteen-minute intervals, year-round. The data loggers are capable of storing up to six (6) months of data. FRCRM staff and contract technicians download data on a bi-monthly interval. This more frequent operation is undertaken to ensure reliable station continuity and detect potential problems that would compromise data reliability. The data from the logger is entered into a laptop computer, station diagnostics are performed, then data is transported to Plumas Corporation and electronically entered into the data archive.

Automated turbidity measurements are being recorded at two (2) stations, Doyle Crossing and Indian Creek- Taylorsville Bridge, using Analite 195 laser sensors, a nephelometric (n.t.u.) probe. This is new technology that the FRCRM considered worthy of demonstration and critique for effectiveness and maintainability.

Figure 4a. is an example of data output that plots the average water temperature for Wolf Creek at Main St. Bridge, one of the instrumented permanent stations. Figure 4b. characterizes output for stream flow at the same location.

Rating Tables are being developed for each permanent station. In order to correlate stage records to stream flow volume, direct flow measurements are conducted at a variety of stages to develop a station-specific rating table. Table 6 is the preliminary rating table for Spanish Creek @ Gansner Bridge. These tables then allow for the assignment of discharge values to the recorded stages in the absence of direct measurement. It is anticipated that an initial minimum of seven readings will be necessary to develop an accurate rating curve, depending on the measurement site characteristics. The opportunity to conduct direct measurement at stages above bankfull (1.5 year return interval) are dependent on infrequent weather events and may require several years to accomplish. Due to instability, some stations may also require rating curves to be periodically re-calculated.

Results and Discussion

Reference Reach Monitoring

Each of the 21 reference reaches were monumented and monitored. One original reach (Hamilton Branch, below Lake Almanor) was exchanged for Goodrich Creek, above Mountain Meadows Reservoir. This was done because of the boulder nature, poor access and the reach lack of ability to respond to Hamilton Branch.

There were no major problems with the monitoring equipment or with the monitoring crew. Crew training took a week in the field during the monitoring of the first two reaches. Data collection oversight and additional training continued to insure that protocols and procedures were followed on each reach. Monitoring of each of the 21 reach took between 16-17 hours once the crew was trained.

The monitoring crew consisted of one Crew Leader (the contractor) and 3 Feather River College students and one crewmember supplied by DWR. It was necessary for the college students to return to college prior to completing all 21 reaches. The last two reaches were completed by the Crew leader and one crewmember.

The collection of maximum sediment lens depth (S*) proved to be unworkable in most of the field conditions encountered and was dropped from data collection. The collection of aquatic fauna data was taken during the last of the four pass taken on each reach. This may have resulted in limited observations of fauna due to the disturbance caused by the first three passes. The installation of temperature data loggers on each reach proved to be difficult for the first monitoring season because the exact location of the reach to be monitored was not determined until a site visit took place. The temperature loggers need to remain at the reach for 60 to 90 days. Reaches monitored later in the field season have no temperature data because loggers could not be installed for the amount of time necessary to follow protocols.

Permanent Station Monitoring

All of the operating stations functioned without failure during the 1999-2000 high runoff period. No loss of data occurred as a result of monitoring equipment failure. On July 2, 2000, the Red Clover Creek at Notson Bridge station was vandalized and the transducer cable was damaged. Replacement was completed on August 11, 2000.

Installation of air temperature sensors was delayed when it was determined that the probes where fabricated incorrectly and had to be returned. A test of the new air temperature probes at Notson indicated that they required special programming which was successfully completed in August 2000. The remaining air temperature probes were installed in the fall of 2000. The data loggers are programmed to record internal temperature that can be used as an indicator of ambient air temperature during the period when the air sensors are not deployed.

During the final phase of discussions regarding station configuration it was determined that an attempt to measure turbidity should be made at two stations. These stations (Taylorsville and Last Chance Creek) were selected primarily do to their ease of installation and the general thinking that they would provide the most useful information. The probe selected to monitor turbidity was the Analite Model 195 nephelometric probe. These units have a built in wiping mechanism that helps to eliminate biofouling caused by long term immersion. The deployment of these probes was delayed by the onset of high flows. These units will be deployed in summer 2001.

In addition to the completion of station installations and special probe deployment, other activities scheduled for 2001 include: compiling and developing the stream stage versus flow relationship to allow conversion of transducer readings to discharge, and a routine maintenance effort at each station to prepare for the high flow period.

Water quality data collected manually by FRCRM staff has not been received from DRI. This is due to the limited amount of samples collected to date. DRI is committed to carrying out this analysis in the upcoming field season when more samples are collected and analyzed.

Recommendations

<u>Reference Reach Monitoring:</u>

For the purpose of the Watershed Monitoring Program, two of the original SCI protocols have been dropped or replaced by other protocols and three additional protocols have been added. Large woody debris (LWD) counts and pebble counts have been dropped from the protocol. Pebble counts have been replaced by the sieve analysis of channel substrate material collected from point bars as well as riffle pavement and sub-pavement.

Pebble counts, while a relatively inexpensive method of characterizing bed surface composition, do not accurately represent all sediment size fractions being transported by the channel in bankfull or greater events. The smaller particle sizes, which will be most affected by changes in watershed condition, are often winnowed out of the surface component by the more frequent, longer duration sub-bankfull flows. Bar and riffle subpavement samples, which are collected below the bed surface and not subject to winnowing, more accurately represent the full range of sediment load. The drawback to this type of sampling is that the processing of these multiple samples is labor-intensive and expensive.

<u>*Recommendation:*</u> Significant changes in channel substrate composition are likely to be relatively slow due to in-channel storage and the infrequent interval of bed mobilizing flows. Therefore, collection and processing of substrate samples should be conducted at every second or third biennial visit, or, the next visit after the watershed has been subjected to a to-be-defined threshold hydrologic event (i.e. 10-year flood).

Water surface longitudinal channel profile survey and macroinvertebrate sampling have been added to the monitoring protocols for this project. Channel profiles are important in helping to determine the changes in the channel configuration, slope and geometry over time. Macroinvertebrate sampling is important in adding a biological element to the monitoring and provides a useful index to assess changes in biological integrity.

Temperature data loggers need to be installed on all reaches prior to the start of the monitoring season and retrieved as soon as the last reach is completed. This will provide the same number of monitored days for each reach. Data loggers need to be cabled into streams and riparian areas to limit loss or theft of the equipment in areas that have high public visitation for recreation.

Recommendation: Maximum sediment lens depth (S*) measurements were originally designed to measure sediment in shallow pools in small wading streams. This proved to be unworkable for most of reaches due to deep pools and low water visibility. The protocol dropped.

Recommendation: Aquatic Fauna data needs to be collected as the first pass before any channel disturbance takes place.

Recommendation: Originally a 5 person crew was used to conduct the monitoring. A crew of 4 would work just as well, especially if some of the measurements may be dropped from the procedure.

All other standard SCI protocols were implemented without undue difficulty and appear to provide useful baseline information.

Permanent Station Monitoring

In general the permanent station installations went well with very few problems. The selected equipment has performed beyond expectations at all locations. The attributes of each station site were thoroughly analyzed prior to selection to balance the opportunities and limitations specific to each. There does not appear to have been any significant deviation from the original analysis.

Installation is a fairly straightforward operation in which a two-person team can easily install one station a day assuming adequate prior material preparation. Adequate material preparation includes having all installation housings prefabricated uniformly, a complete selection of mounting hardware of various sizes and types, drilling templates, extra tool bits, batteries and a fully programmed logger with wiring diagrams.

Since initial installation, the only failure was gunfire vandalism at the Notson Bridge site. Bullets pierced the cable conduit and severed the sensor cables.

Recommendation: At this juncture no changes are recommended.

Flow and sediment monitoring

Streamflow monitoring has been conducted, and continuing at each of the stations. To date, this has been accomplished with the primary objective of developing a discharge rating table for each station. Since station installation there have been only modest changes in streamflow at any of the stations. This condition has resulted in very few (average of 3/station) streamflow measurements being conducted. Each direct measurement has an average cost of approximately $200.00. In order to maximize the utility of these initial measurements, stage change thresholds to be measured were identified and prioritized that would provide reliable data points for rating table development. At most stations streamflows have not yet reached many of these threshold points. In general, the intent was to conduct several measurements at/near summer baseflow, then conduct measurements a .5’ increments and, whenever a significant change in channel form occurred (bankfull stage, full-wetted gully, etc.). Most of the monitored streams have not achieved even a bankfull stage since station operations began.

More intensive streamflow monitoring will be conducted at those stations where sediment monitoring is being undertaken. Each time sediment sampling is conducted a flow measurement will be performed, regardless of the above described stage thresholds. These activities will generally be conducted and funded under the scope of other watershed projects, such as Proposition 204 and will augment the trend monitoring program. For the same reasons cited above, lack of streamflow, minimal sediment monitoring has been accomplished to date.

Recommendation: No changes are recommended at this time.

References:

"Stream Condition Inventory Guidebook" version 4.0, United Stated Department of Agriculture, Forest Service, Pacific Southwest Region, 1998.

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